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(54) **Navigation apparatus for land vehicles**

(57) Signals produced from one or more transmitters of known position, e.g. satellites of the "Global Positioning System" are received by a receiver 1 of a land vehicle, are evaluated and a mean value is formed. A direction sensor 7 and a distance recorder 6 produce separate direction and distance signals which are fed to a computer 4, which by means of the dead reckoning navigation method determines therefrom the position of the vehicle which is indicated by an indicator 5. For the correction of the indicated position of the vehicle the indicator 5 is adjusted at predetermined time intervals to the mean value of the signals received from the more accurate receiver 1.

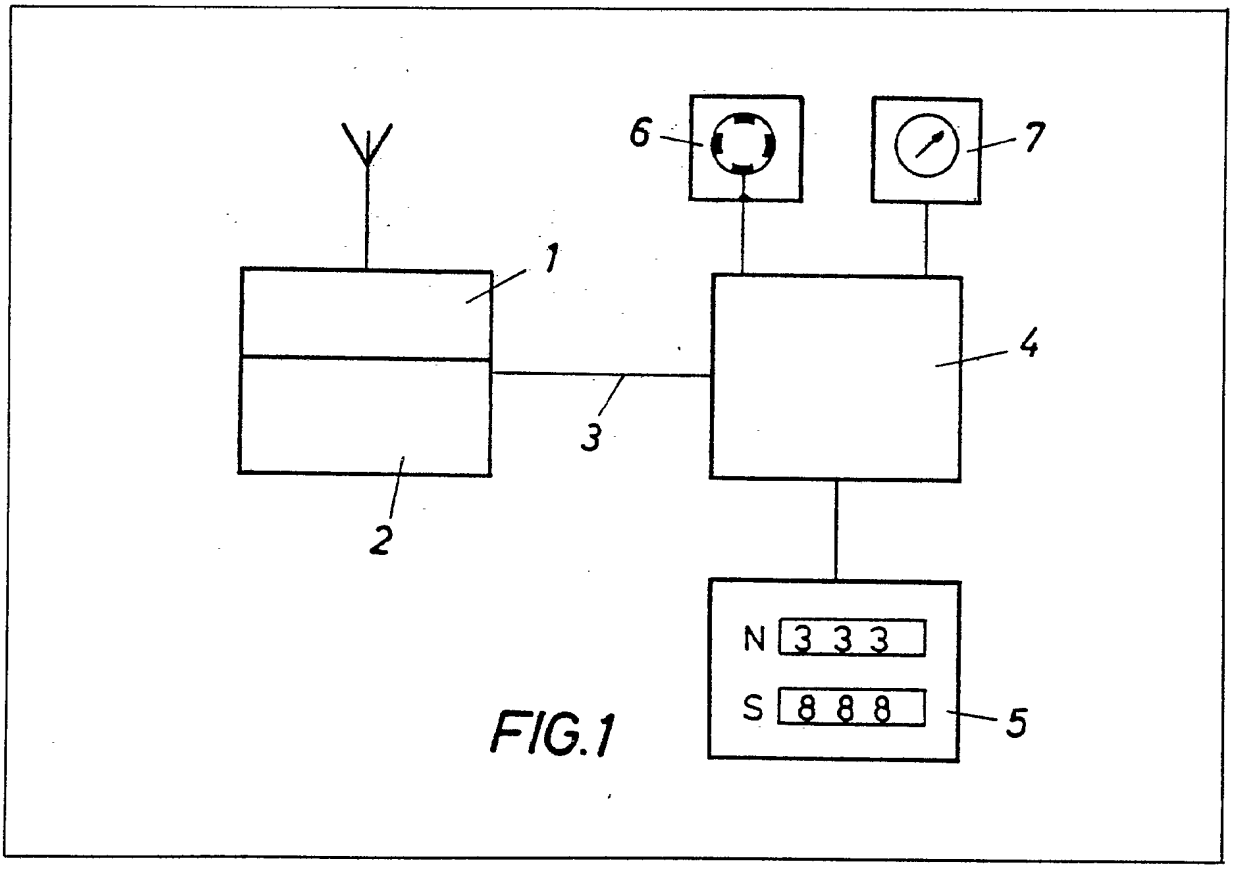

FIG.1

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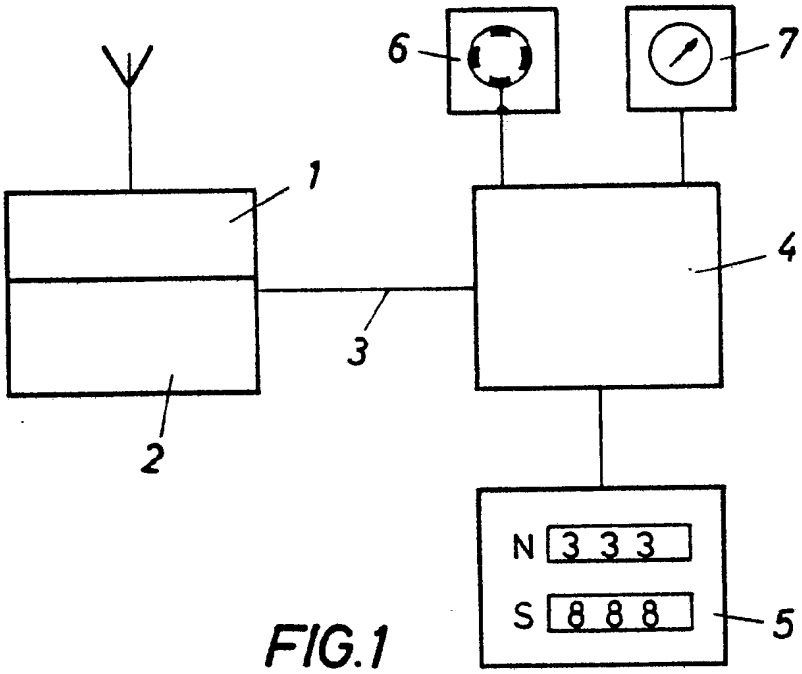

FIG.1

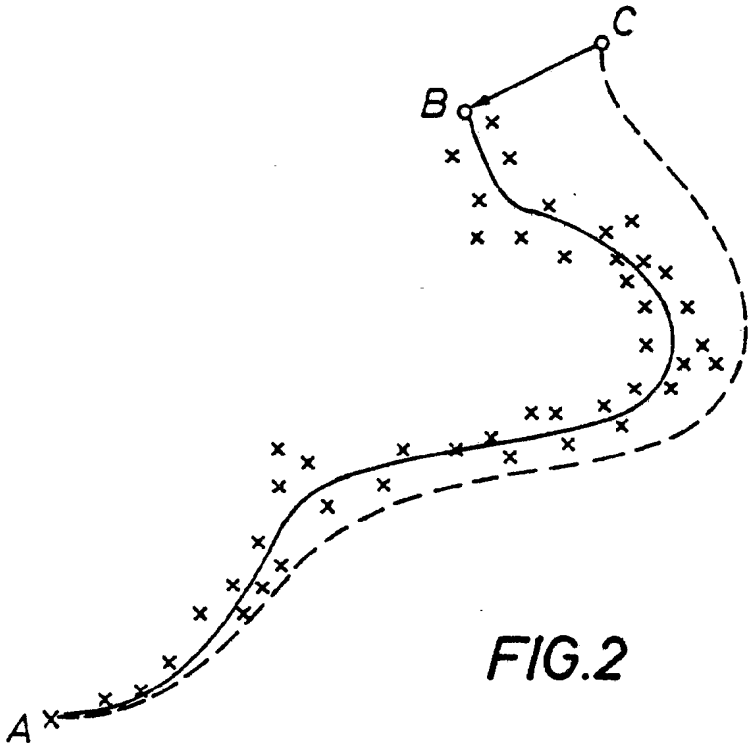

FIG.2

SPECIFICATION

Navigation apparatus for land vehicles

The present invention relates to a navigation apparatus for land vehicles and more particularly to a navigation apparatus, containing a location system, in which the signals transmitted from at least one transmitter of known position are exploited by the evaluation of transit time dependent and/or phase dependent effects for the determination of the position of a receiver arranged in the vehicle, and an additional self-contained navigation system arranged in the vehicle. By means of measured value detectors which are less accurate than the location system and which detect the path covered and the direction of travel, the navigation system continuously determines the positional coordinates of the vehicle.

The present invention seeks to permit a reliable correction of the determined positional coordinates.

According to a first aspect of the present invention there is provided a navigation apparatus for a land vehicle comprising a location system including a receiver arranged to be carried by a vehicle and in which signals from at least one transmitter of known position are used to determine the position of said receiver, and a separate navigation system comprising means for detecting the distance covered and the orientation of the vehicle, said detecting means being less accurate than said location system, the navigation system being arranged to continuously determine the positional coordinates of the vehicle, wherein the location system is arranged to produce positional data at short time intervals, and there is provided computing means, which is arranged to determine the probable course of the journey from a plurality of successively-received positional data, and means responsive thereto for correcting the positional coordinates determined by the separate navigation system.

According to a second aspect of the present invention there is provided a navigation apparatus for a land vehicle comprising a first location system and a second, less accurate location system, output signals from the first system being arranged to correct the output of the second system.

Known methods of location include hyperbolic or asymptotic methods. In particular, however, the apparatus is arranged for use in location methods using satellites as transmitter carriers and in especially in location methods known under the name GPS (Global Positioning System). This is fully described for example in the brochure "Global Positioning System" — Papers, published in NAVIGATION published by "The Institute of Navigation," Washington, D.C., Copyright 1980. For example it is explained in the paragraph "GPS Receiver Operation" on page 81 et seq., that in this system simple receivers can also be employed, for example single channel receivers; these receive the signals from the, in general, four transmitters in a serial manner and evaluate them.

In a development of the invention it is suggested that, by means of the formation of measured values, the location data produced at short time intervals may be approximated to the actual course of the journey.

Here several methods are suitable, for example the method of least squares, the formation of the reciprocal mean value, the geometrical mean value or others.

According to a further development the measuring points and/or the positional data are provided with a weighting factor, in which for example the weighting factor has a decreasing tendency with increasing separation of the measuring points from the actual course of the journey.

The errors in the measured value detectors, for example the randomly determined drift of the course detector or control or an error in the path, can be compensated from the correction of the positional coordinates so that the position determined by means of the dead-reckoning reproduces the actual position with greater accuracy.

As direction indicator or course detector there may be used an inertial mass body as disclosed in DE—OS 29 36 774, which upon rotational movements of the vehicle about the main axis maintains its initial orientation and with which the course alteration can be plotted via a coded disc. It is also possible to process the signals of a rotational speed measured value indicator at the steered wheels of a vehicle, such as are employed in anti-blocking control systems for example. The difference between the signals per unit of time and related to the speed represents a measure of the alteration in direction of the vehicle. The averaged signals per unit of time represent a measure for the distance travelled. From the alterations in direction and the overall direction determined by the calculation between the individual positions there results the current direction of travel of the vehicle, for example with reference to North.

A preferred embodiment of the present invention will now be described by way of example only, with reference to the accompanying drawings of which:

Figure 1 show a block circuit diagram of a navigation apparatus according to the present invention; and

Figure 2 shows a sketch of the course of a journey.

A receiver 1 shown in Fig. 1 receives in a multiplexing process the signals transmitted from transmitters, for example from four satellites. These are converted on the basis of travel time — or phase — dependent effects in a decoder 2 connected at the output and fed as positional data via a signal line 3 to a computer 4. The computer stores these data and forms respective average values after predetermined intervals of time. To obtain a continual indication of position, there is further provided a direction sensor 7 and a

distance recorder 6, of which the signals are also fed to the computer 4 and from which the actual position is ascertained continuously according to the dead-reckoning navigation method and is indicated on an indicator unit 5, for example by means of a digital indication or by means of a map apparatus.

The course of the journey travelled, as it is determined by means of the direction sensor and distance recorder, is represented in Fig. 2 by the line A—C. It is clear that both a distance recorder and direction sensor contain a certain uncertainty in measurement, determined by drift errors, slippage errors or other disturbances, so that after a certain distance travelled the indicated point C does not agree with the actual position of the vehicle. It is therefore provided that the positional data represented in Fig. 2, which occur at short intervals of time and whose mean value forms the line A—B, are used as a correction of the indicated position. The difference in coordinates between the points C—B is fed to the indicator, i.e. for the following part of the journey the point B is the staring point, which also agrees essentially with the actual position.

In one enlargement an initial determination of the direction of the vehicle relative to a reference direction results from a manual coarse orientation on the basis of known data, for example marked ground reference points.

CLAIMS

1. A navigation apparatus for a land vehicle comprising a location system including a receiver arranged to be carried by a vehicle and in which signals from at least one transmitter of known position are used to determine the position of said receiver, and a separate navigation system comprising means for detecting the distance covered and the orientation of the vehicle, said detecting means being less accurate than said location system, the navigation system being arranged to continuously determine the positional coordinates of the vehicle, wherein the location system is arranged to produce positional data at short time intervals, and there is provided computing means, which is arranged to determine the probable course of the journey from a plurality of successively-received positional data, and means responsive thereto for correcting the positional coordinates determined by the separate navigation system.

2. An apparatus according to claim 1, wherein the location system employs transit-time dependent effects.

3. An apparatus according to claim 1 or 2, wherein the location system employs phase dependent effects.

4. An apparatus according to any preceding claim, wherein the probable course of the journey is the geometrical mean value of the positional data.

5. An apparatus according to any preceding claim wherein the probable course of the journey is determined according to the method of least squares.

6. An apparatus according to any preceding claim, wherein the positional data are provided with a weighting factor.

7. An apparatus according to any preceding claim, wherein the errors caused by the detecting means are compensated on the basis of the correction of the positional coordinates of the seaparate navigation system.

8. An apparatus according to any preceding claim, wherein the detecting means comprises two rotational speed sensors arranged to be located at the wheels of an axle of a vehicle and wherein the direction alteration of the vehicle is determined from the difference in rotational speed of the wheels.

9. An apparatus according to any preceding claim, wherein the detecting means for determination of the orientation of the vehicle operates according to the inertial principle.

10. An apparatus according to any preceding claim, wherein an initial determination of the direction of the vehicle relative to a reference direction results from a manual coarse orientation on the basis of known data.

11. An apparatus according to claim 10, wherein the known data comprises marked ground reference points.

12. An apparatus according to claim 5, wherein the north direction is ascertained from the correction.

13. A navigation apparatus for a land vehicle comprising a first location system and a second, less accurate location system, output signals from the first system being arranged to correct the output of the second system.

14. A navigation apparatus substantially as herein described with reference to the accompanying drawings.

15. A method of navigating a land vehicle employing a navigation apparatus as claimed in any preceding claim.

16. A method of navigating a land vehicle substantially as herein described with reference to the accompanying drawings.

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